

National Aeronautics and
Space Administration



Innovation & Opportunity

VIRTUAL CONFERENCE

Propelling your business. Transitioning your technology.

October 20–22, 2020

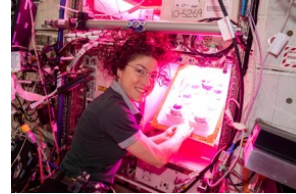


Mission Directorate Vision: Human Exploration and Operations

Lindsay Aitchison

NASA Headquarters, HEOMD

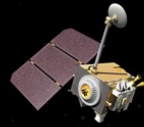
HEO Organization



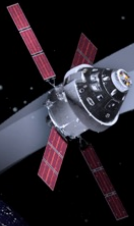
- Provides the Agency with leadership and management of NASA space operations related to human exploration in and beyond low-Earth orbit.
- Responsible for Agency leadership and management of NASA space operations related to Launch Services, Space Transportation, and Space Communications in support of both human and robotic exploration programs.
- The International Space Station, currently orbiting the Earth with a crew of six, represents the NASA exploration activities in low-Earth orbit.
- Exploration activities beyond low-Earth orbit include the management of Commercial Space Transportation, Exploration Systems Development, Human Space Flight Capabilities, Advanced Exploration Systems, and Space Life Sciences Research & Applications.

<https://www.nasa.gov/directorates/heo>

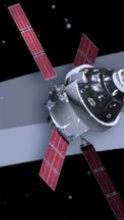
ARTEMIS: Landing Humans On the Moon in 2024



Lunar Reconnaissance Orbiter: Continued surface and landing site investigation



Artemis I: First human spacecraft to the Moon in the 21st century



Artemis II: First humans to orbit the Moon and rendezvous in deep space in the 21st Century



Gateway begins science operations in lunar orbit with launch of Power and Propulsion Element and Habitation and Logistics Outpost



Initial human landing system delivered to lunar orbit

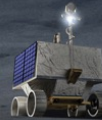


Artemis III: Orion and crew dock to human landing system for crew expedition to the surface



Early South Pole Robotic Landings

Science and technology payloads delivered by Commercial Lunar Payload Services providers



Volatiles Investigating Polar Exploration Rover

First mobility-enhanced lunar volatiles survey



Humans on the Moon - 21st Century

First crew leverages infrastructure left behind by previous missions

LUNAR SOUTH POLE TARGET SITE

ARTEMIS: Extending Lunar Missions to Prepare for Mars



International habitat delivered to Gateway, in-situ resource utilization (ISRU) demonstrations on the surface and LTV to expand exploration range

Artemis IV: First lunar surface expedition through Gateway. External robotic system added to Gateway

Sustainable operations with reusable landing system and enhanced lunar communications, refueling, and viewing capabilities on Gateway

Airlock arrives at Gateway; surface habitat and pressurized rover delivered to expand exploration range and crew size

Enhanced habitation capability delivered to Gateway for Mars dress rehearsals

Lunar Terrain Vehicle (LTV)

Surface Habitat

Pressurized Rover

Fission Surface Power

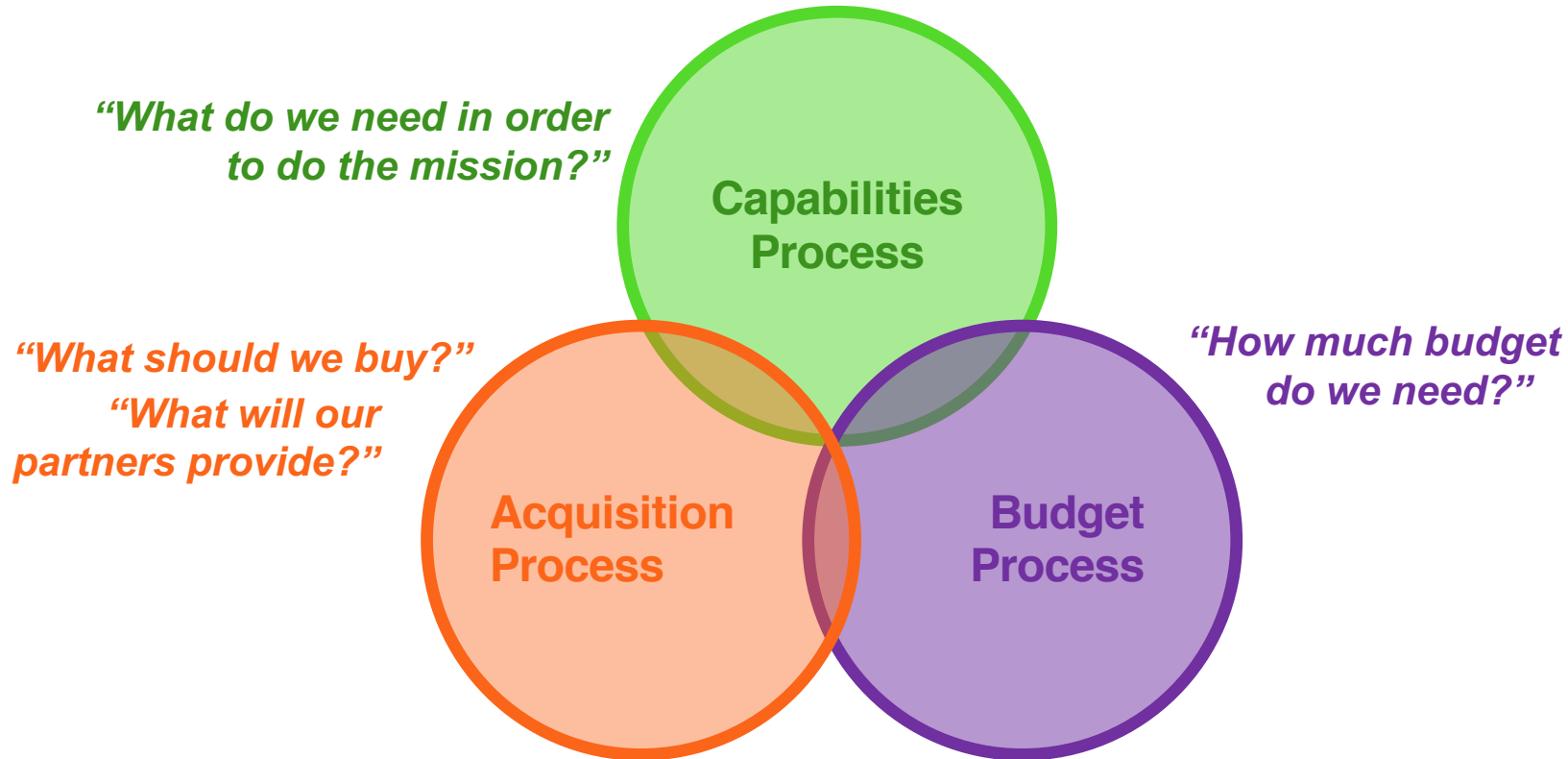
ISRU Pilot Plant

SUSTAINABLE LUNAR ORBIT STAGING CAPABILITY AND SURFACE EXPLORATION

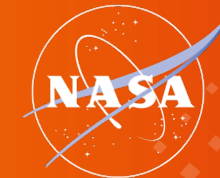
MULTIPLE SCIENCE AND CARGO PAYLOADS | U.S. GOVERNMENT, INDUSTRY, AND INTERNATIONAL PARTNERSHIP OPPORTUNITIES | TECHNOLOGY AND OPERATIONS DEMONSTRATIONS FOR MARS

All contents represent notional planning and are for discussion purposes only

Identifying Capability Gaps

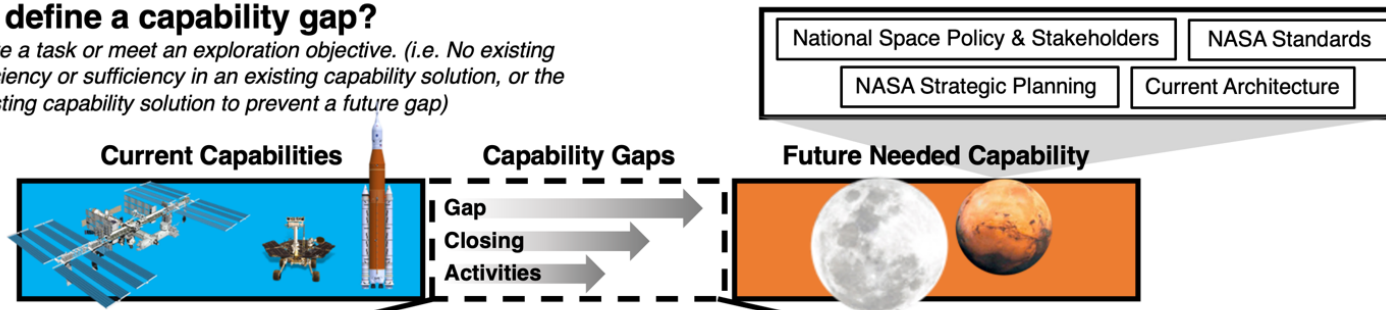


Capabilities Integration Framework

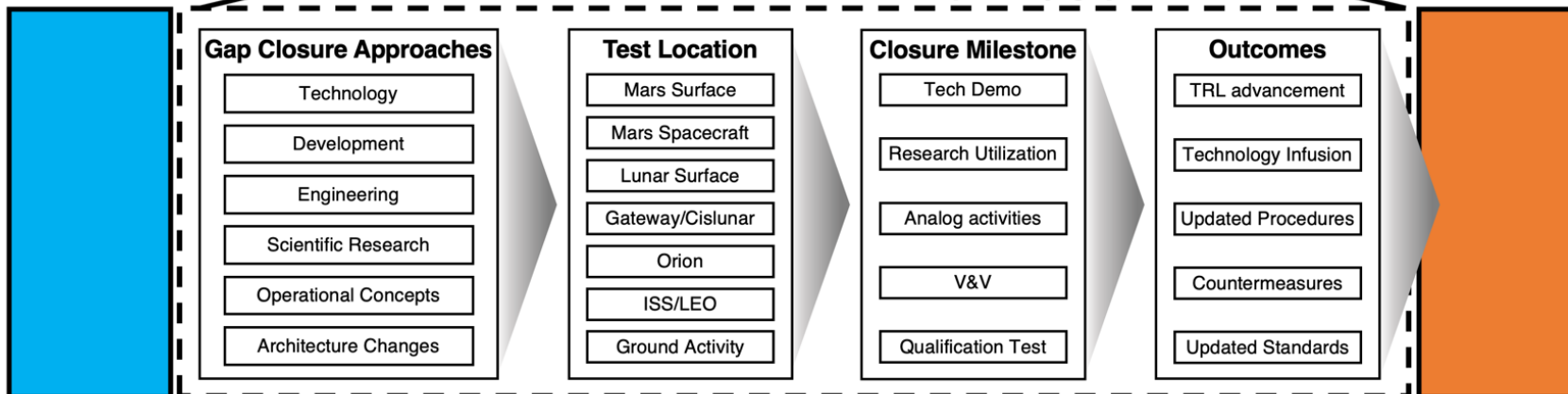


1. How do we define a capability gap?

The inability to complete a task or meet an exploration objective. (i.e. No existing capability, lack of proficiency or sufficiency in an existing capability solution, or the need to replace an existing capability solution to prevent a future gap)



2. What is needed to close these capability gaps?

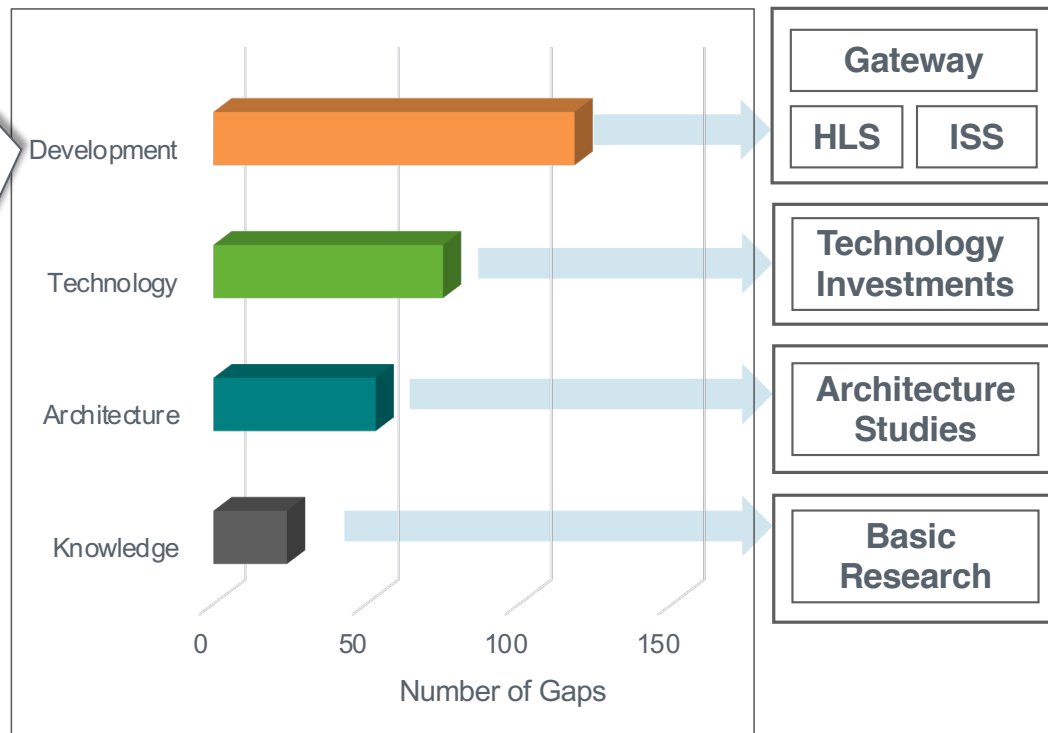


Capability Gap Closure Pathways



Development Gap Examples

- Adaptive Space Network Management/Cognitive Networking
- Autonomous logistics tracking and manipulation
- Microbial monitors for air, surface, and water that provide in-flight analysis
- Implementation of autonomy in various vehicle systems



Results from 2019 Data Call Shown

Multiple possible architectures considered

Approximately 270 proposed gaps in total when all architecture options included

HLS = Human Landing Systems

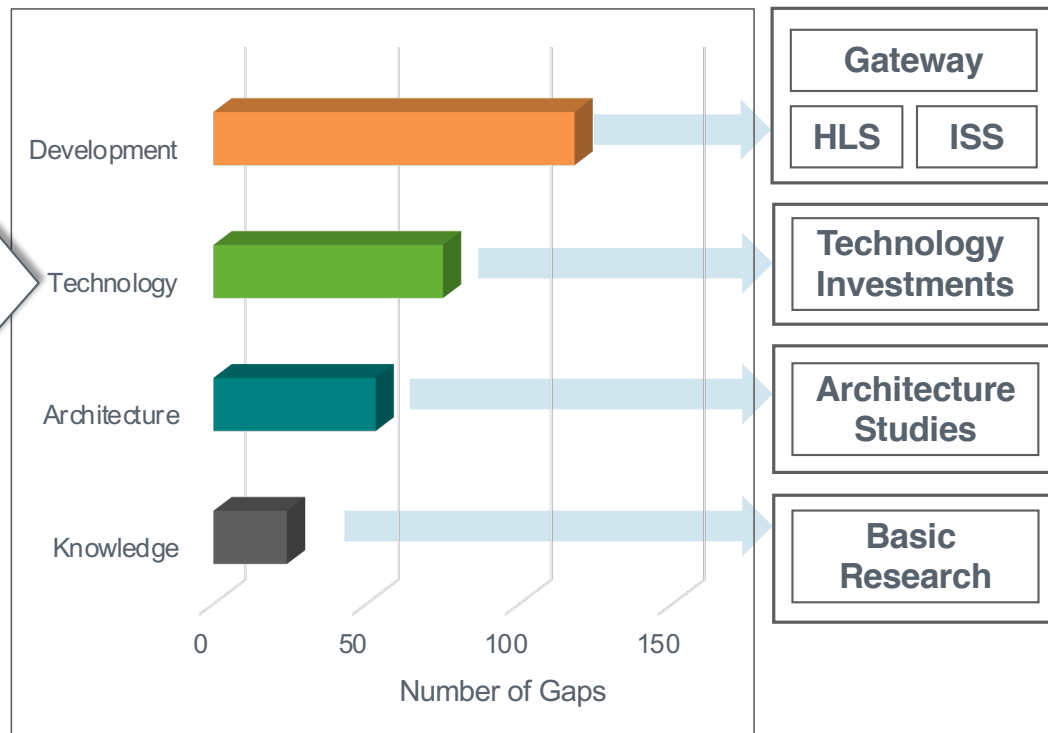
ISS = International Space Station

Capability Gap Closure Pathways



Technology Gap Examples

- Cryogenic Propellant In-Space Transport and Refuel
- Mitigation of Microbial Growth in Spacecraft Systems
- Durable Spacesuit Heat Rejection
- Components that tolerate Extreme Temperature, Radiation, and Dust Conditions



Results from 2019 Data Call Shown

Multiple possible architectures considered

Approximately 270 proposed gaps in total when all architecture options included

HLS = Human Landing Systems

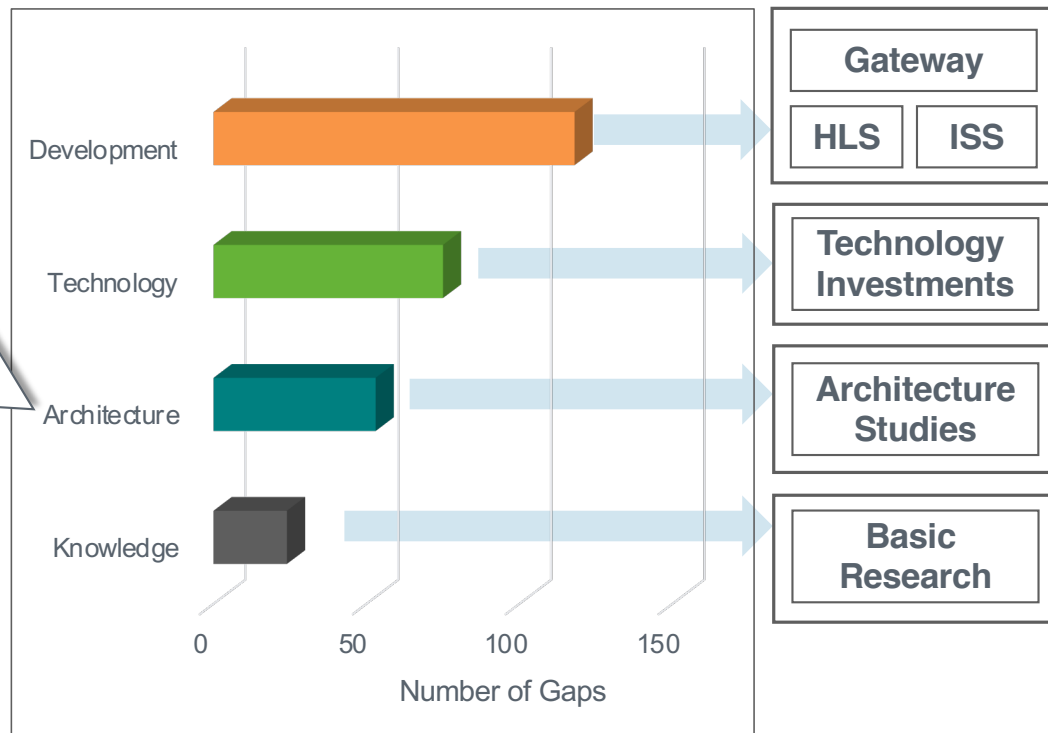
ISS = International Space Station

Capability Gap Closure Pathways



Architecture Gap Examples

- Power Generation, Storage, and Distribution Architecture
- EVA Concept of Operations
- Logistics and Sparing Strategy



Results from 2019 Data Call Shown

Multiple possible architectures considered

Approximately 270 proposed gaps in total when all architecture options included

HLS = Human Landing Systems

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Capability Gap Closure Pathways



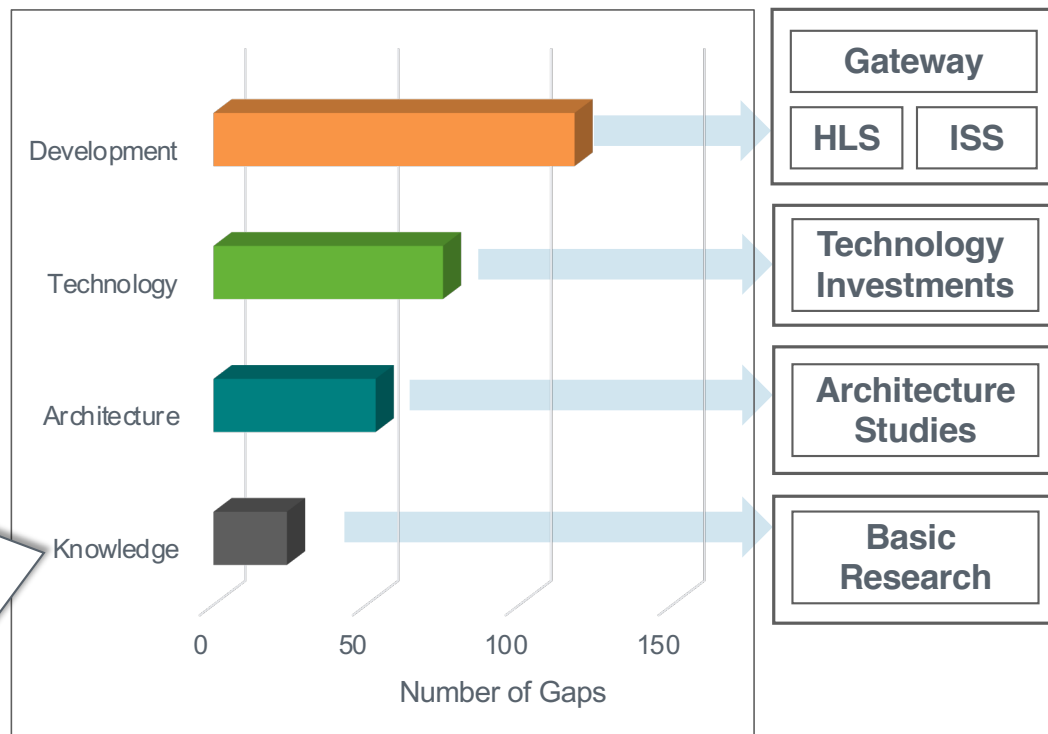
Knowledge Gap Examples

- Degradation of Landed Materials in Lunar & Martian environments
- Impact of altered gravity fields on human health & performance
- Low and Partial Gravity Material Flammability

Results from 2019 Data Call Shown

Multiple possible architectures considered

Approximately 270 proposed gaps in total when all architecture options included

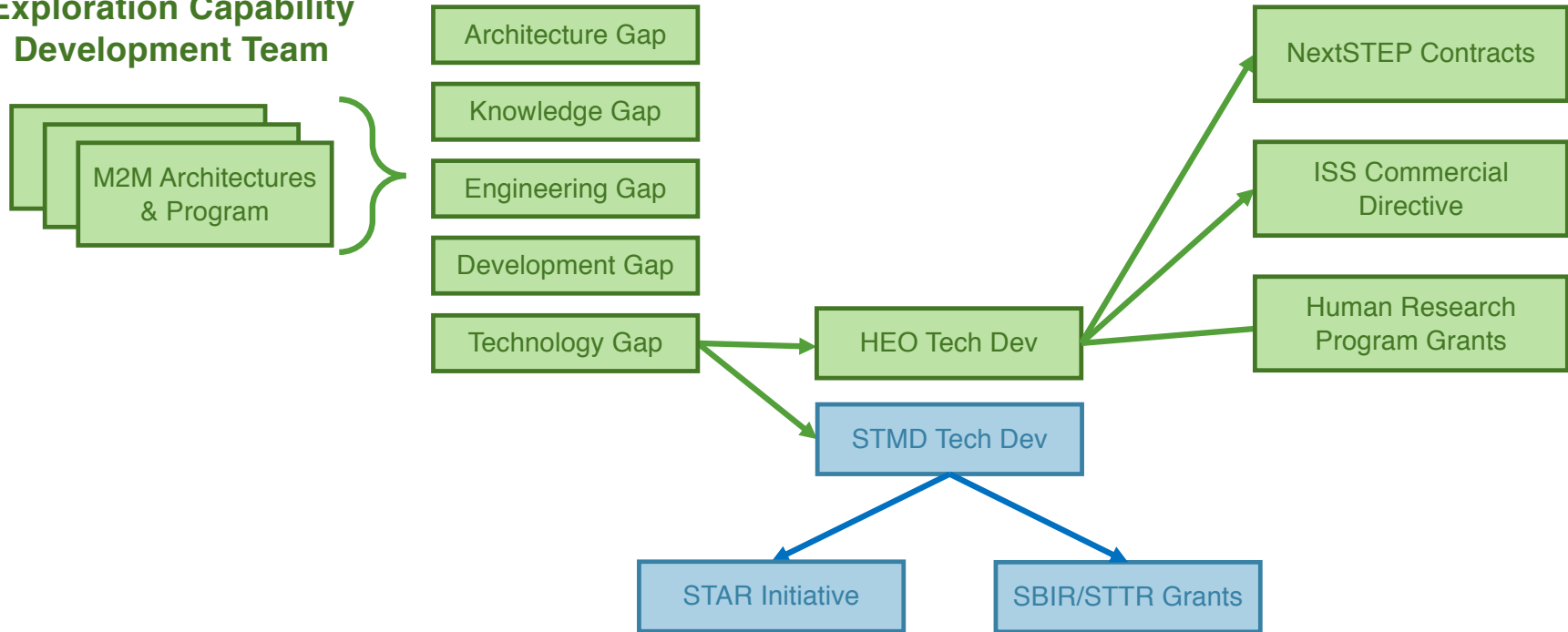


HLS = Human Landing Systems
ISS = International Space Station

Investing in Technology Development



Exploration Capability Development Team



NextSTEP-2



- A public-private partnership model seeking commercial development of deep space exploration capabilities to support human spaceflight missions
 - Open to all categories of U.S. and non-U.S. institutions (NASA Centers and other FFRDC and Government agencies, companies, universities, nonprofit organizations)
 - Eligibility for participation is tailored for each research area.
 - New solicitations (appendices) added on rolling basis
- Past solicitations:
 - Appendix A - Habitation Systems
 - Appendix B - FabLab
 - Appendix C - Power and Propulsion Element Studies
 - Appendix D - In-situ Resource Utilization
 - Appendix E - Human Landing System Studies, Risk Reduction, Development, and Demonstration
 - Appendix F - Trash Compaction and Processing
 - Appendix G - Space Relay Partnership and Services Study
 - Appendix H - Human Landing System
 - Appendix I - Commercial Destination Development in Low Earth Orbit using the International Space Station
 - Appendix J - Opportunities to Stimulate Demand in Low Earth Orbit through Applied Research
 - Appendix K - Commercial Destination Development in Low-Earth Orbit (LEO) Free Flyer

Human Research Program



- NASA's Human Research Program (HRP) Objectives:
 - Quantification of the crew health and performance risks associated with human spaceflight for the various exploration missions.
 - Development of countermeasures to provide mission planners and system developers with strategies for mitigating crew health and performance risks.
 - Development of technologies to provide mission planners and system developers with strategies for monitoring and mitigating crew health and performance risks.
- Red Risk School: An Introduction to Human Health Risks in Deep Space
 - Annual seminar series connects the dots between NASA's top risks, uncovers opportunities to translate research in all fields for use in space, and explains the funding opportunities available for scientists and entrepreneurs with space-translatable research
 - Find past sessions on YouTube: <https://www.youtube.com/playlist?list=PLB0msUc7n7OOWd75Qills03nRw3NQ7eEX>
- Translational Research Institute for Space Health (TRISH)
 - Targets high-risk early-stage research as well as pre-seed and seed-stage health technologies to support astronauts on the way to Mars
 - Variety of funding opportunities with awards from \$100k-\$500k
- Human Exploration Research Opportunities (HERO)
 - Omnibus solicitation for short-term investigations and technology development
 - New solicitations (appendices) posted on rolling basis

ISS Commercialization Directive



- Commercial directive enables commercial manufacturing and production and allows astronauts to conduct new commercial activities aboard the orbiting laboratory
- Research Opportunities for International Space Station Utilization Solicitation: NNJ13ZBG001N
 - Focus Area 1: Demand Stimulation
 - Targeting in-space manufacturing, regenerative medicine, and other critical research areas that derive unique benefits from the microgravity environment
 - Intent is to offer a series of targeted awards in three Phases:
 1. Early concept development (awards nominally up to \$200k),
 2. Design maturation and prototype development (awards nominally up to \$1.5M), and
 3. Flight hardware production and in-flight operations to gain actual experience in the LEO environment (awards nominally up to \$5M).

How HEO Infuses SBIR Technologies

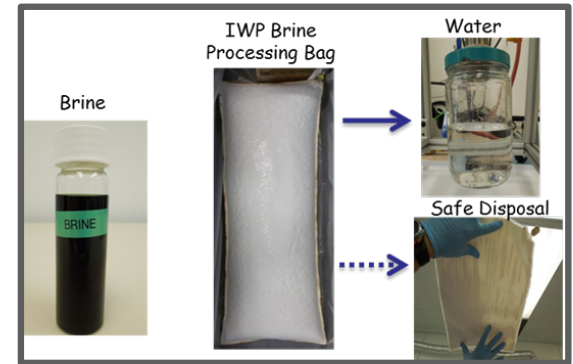


- SBIR technologies can be rolled into larger system development
 - Exploration Capabilities development project
 - Direct pull into a flight development program
- Tech Monitors are the key champions for transitioning SBIR Phase I activities
 - In many cases, have decision authority within NASA development activities that benefit from the technology
 - Identify customers for cost-sharing in Phase III
 - Provide increased context and requirements for technology infusion into systems
- ISS utilization topics have led to permanent capabilities on ISS

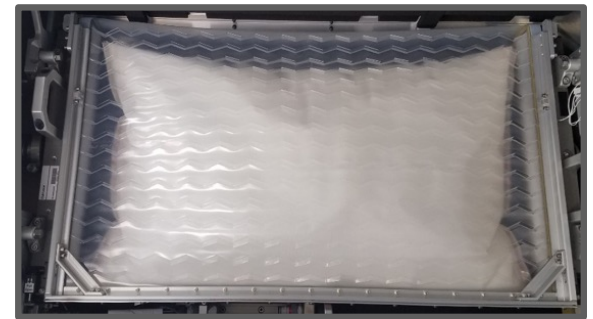
HEO Success Story: Ionomer-membrane Water Processor



- NASA Problem: For regenerative wastewater recycling systems, brine wastewater production results in a considerable loss of water on a yearly basis. It is highly toxic. Consumable containers are used to dispose of the brine, which adds significant consumable mass.
- SBIR Awarded to Paragon Space Development Corp. for Ionomer-membrane Water Processor (IWP)
 - SBIR Phase 1 Awarded: 2/18/2011
 - SBIR Phase 2 Awarded: 5/18/2012
 - SBIR Phase 3 Awarded: 4/13/2015
- Technology was competitively selected for infusion into Brine Processor Assembly (BPA) Project under Advanced Exploration Systems
 - Using SBIR technology, BPA will improve water recovery process on the ISS by increasing water loop closure to >98%, meeting the technology maturation objective for human missions to Mars.
 - The ISS demo will validate and fully characterize Brine Processor system performance in a relevant environment for future exploration missions.
 - This test will define the state of the art for recovery of potable water from wastewater.
- Objective: Recover up to 80% of available water from 22.5 liters of brine within a 26-day cycle. BPA consumables (bladders) mass shall not exceed 0.25 lb hardware for every lb of water recovered from brine.
- **Status:** BPA will be delivered for flight in Feb 2020.



IWP functional description



**ISS Brine Processor Assembly –
Brine bladder installed**

Key References



- Research Opportunities for iSS Utilization Solicitation:
<https://nspires.nasaprs.com/external/solicitations/solicitationAmendments.do?solId=%7B21E0270C-BC1F-EFC4-3D87-30713B5FF373%7D&path=&redirectURL=>
- NextSTEP-2 Overview: <https://www.nasa.gov/content/nextstep-overview>
- Translational Research Institute: <https://www.bcm.edu/academic-centers/space-medicine/translational-research-institute>
- Red Risk School Red Risk Playlist:
<https://www.youtube.com/playlist?list=PLB0msUc7n7OOWd75Qills03nRw3NQ7eEX>
- NASA Human Exploration Research Opportunities:
<https://nspires.nasaprs.com/external/solicitations/summary.do?solId={D4076210-8F49-DC60-3C00-65ED26FE9EC7}&path=&method=init>
- NASA SBIR Program: <https://sbir.nasa.gov/>